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A METHOD OF REPAIRING A PEDESTAL SURFACE

Field of the Invention

The present invention relates to repairing pedestal surfaces, in particular the top surfaces of pedestal heaters, for instance as are used in chemical vapour deposition (CVD), physical vapour deposition (PVD), semiconductor metal and oxide etching processes or semiconductor processing equipment that require heating or a vacuum to secure the position of a wafer to the pedestal surface.

Background of the Invention

Pedestal heaters are for instance used in vapour deposition and etching techniques. The pedestal stands within a reaction chamber, with a wafer sitting atop the pedestal. During the deposition process a reactive gas enters the chamber and is deposited on the wafer, the wafer itself being heated by a heater mechanism within the pedestal.

The wafer is usually clamped to the top of the pedestal by way of differential pressure clamping or electrostatic clamping. Additionally back gases are emitted from the pedestal, around the edges and the centre of the wafer to prevent deposition on the back of the wafer and to provide uniform heat transfer to the wafer. In the case of a multiple pedestal heater chamber, edge purging is introduced to reduce cross deposition and contamination. The various requirements for the pedestal result in a number of channels across its top surface.

A pattern of channels on the top surface of a pedestal 10 is shown in Figure 1. A series of radial channels 12 emerge from a central hole 14 and extend as far as an annular channel 16. Together these channels are used in applying a differential pressure to a wafer. During use, a circular wafer 18 covers the radial channels 12 and the annular channel 16 completely and when a vacuum pressure from a pedestal vacuum pump is connected to the central hole 14, the differential between the pressure in the chamber and the pressure in the channels causes the wafer 18 to be clamped firmly to the pedestal. Typically a chamber pressure is about 40 Torr,

whereas the backside pressure < 20 Torr. An additional annular groove 20 extends beyond the outside of the differential pressure channel 16. This is a purge groove, which is fed by a number purge gas passages 22 below the surface (and not generally visible. During use, the wafer 18 sits on the pedestal with its edges extending beyond the inner wall 24 of the annular purge groove 20, but not as far as the outer wall 26. Back gases pass through the purge gas channels and are blown out around the outer edge of the circular wafer 18. Three lift pin openings 28 are also provided in the top surface. After processing, pins in these push a wafer upwards to allow it to be more easily removed from the pedestal.

Pedestal heaters are used in processing chambers, for instance with five such heaters in a single chamber. Preventative maintenance in the form of chamber wetcleans takes place at intervals based on duration usage and/or throughput usage. With frequently used chambers, such maintenance may be after every 10,000 wafer runs, which may, for example, be every 14 to 21 days. Such regular maintenance helps to maximise hardware performance and process consistency/repeatability. During the maintenance, all the pedestal heaters in the chamber are checked for defects and normally two to three of them will be found to be out of specification, by way of clamping tests. Such tests are run to ensure that a wafer will be correctly mounted and clamped. The pedestal vacuum pump is started and purging Argon gas provided into the chamber. Once the vacuum pressure has stabilised, a pressure reading is taken. If it is too high, this suggests leakage and something must be done about it. For example, during a test when the chamber is at atmospheric pressure, the pressure on the back of the wafer is expected to be about 15 Torr or less. If the back pressure is significantly greater than this, a repair is attempted on the pedestal surface. If the completed repair fails to bring the pressure down the pedestal is replaced at great expense.

A typical repair procedure involves placing isopropyl alcohol (IPA) onto a bare silicon wafer, placing the wafer onto the pedestal (IPA side down). The wafer is then moved on the top of the pedestal in a figure of eight pattern for 30 seconds, using the IPA as lubrication. The wafer is removed and the pedestal surface wiped with IPA and a wipe to remove particulates. Once the remaining IPA has been allowed to dry on the pedestal, it is tested again to see if the pressure is sufficiently

low. If it is not, the procedure is repeated, until the pressure comes down or until it becomes clear that it will not come down within normal maintenance times. At which point it becomes more cost effective to give up and replace the pedestal heater.

The problem with this method is that it can take between two to three man-hours to repair a single pedestal. Further, whilst the pressure differential is improved, the result is still not as good as is desired, for instance the temperature in a wafer, heated by the pedestal may still not be uniform and quite often the pedestal can fail again within a relatively short period. Even with such repairs, distortion on the heater surface accumulates until such time as this approach can no longer achieve suitable a backside pressure and the heater must be replaced. In general, the heater lifetime cannot be extended for more then six months after this repair.

The inventors for the present invention have determined that the reason for the breakdown in pressure differential is due to distortions in the pedestal top surface 28 that accumulate through repeated used. These damaged areas tend to be the edges, for instance around the lift pin openings 28, central gas hole 14, side purge holes (not shown) etc. where heat dispersion is greatest, the top of the central gas hole 14 being shown in cross-section in Figure 2. This is due to the constant cycle of expansion and contraction.

Additionally, there can be other types of heater defects, for example: A) Under-Etching during "Plasma clean" (to remove all traces of Tungsten from the entire chamber before it is open for wetclean), due to a defective endpoint detector or RF generator (an endpoint detector detects plasma wavelengths and whether the tungsten film is completely removed from the chamber and commands that the plasma clean is stopped. If it is faulty then the chamber will not be cleaned. Likewise, the RF generator is an energy device for forming plasma and the chamber will not be cleaned if the generator is faulty); B) When a wafer is broken and leaves parts of itself on top of the pedestal heater, such wafer chips act as a mask which inhibits the removal of tungsten metal during plasma cleaning; and C) Minor scratches on the heater surface that induce vacuum leakage. As the top surface distorts portions 34 at the edges of the channels are raised up, the flat wafer 18 is

no longer in contact with the pedestal surface 32 across its entire area, with gaps occurring which allow pressure leakage.

With the above in mind the present invention resulted from a desire to improve the pedestal repair process.

Summary of the Invention

According to one aspect of the invention, there is provided a method of repairing a pedestal surface, comprising the step of polishing said surface using a coarse surface of a film.

According to another aspect of the invention, there is provided a method of repairing a pedestal surface, comprising the step of polishing said surface using a coarse surface with a coarseness of from 1 to 45 microns.

Preferably, the coarse surface comprises diamond grains.

According to yet another aspect of the invention, there is provided a pedestal repaired according to one of the methods above.

According to again another aspect of the invention, there is provided a pedestal repair apparatus comprising a silicon wafer, with a coarse film on one side thereof.

More specifically, the invention is exemplified by a method of repairing a pedestal heater using a diamond film stuck onto a silicon wafer to polish the surface of the heater and so remove distortion, coatings or surface scratches.

Introduction to the drawings

The present invention will be further described by way of non-limitative example, with reference to the accompanying drawings, in which:-

Figure 1 is a top plan view of a typical pedestal design;

Figure 2 is a cross sectional view through a portion of a used pedestal; and

Figure 3 is a flow chart relating to a method according to an embodiment of the invention.

Detailed description

The inventors have therefore sought a way of repairing the surface of the pedestal to remove the distortion, coatings or scratches to the top surface of the pedestal. They have developed a method as is now described.

Firstly a polisher is prepared. At the start (S100), this involves laminating tape onto one surface of a wafer (S102), preferably the shining surface, the wafer ideally being blank. A plastic polymer tape will suffice. Silicon wafers break easily during the polishing process. This tape is used to hold up loose wafer chips when breakage occurs (reducing the number of particles). It can also prevent accidental cuts to a user's fingers as well as providing an improved grip.

A mineral oil is applied (S104) to the other side of the dummy wafer (that is the side without the tape on it). Preferably this mineral oil should be friendly to semiconductor parts and processes. For instance, the oil could be a fluorinated oil, such as perfluoroalkylether oil. It is preferably highly viscous and relatively inert, with low volatility and low toxicity. Polymerisation should not occur at room temperature. A roller is used to spread the mineral oil evenly on the wafer (S106), without allowing it to seep out beyond the edges. A sheet of diamond lapping film is then stuck onto the wafer (S108), effectively using the oil as an adhesive. Bubble formation between the back of the lapping film and the wafer is prevented by the even spreading of the oil.

Diamond is the preferred choice for the lapping film, although not essential. The lapping film should typically have a grade of from 1 to 45 microns, for instance 9-micron grade works well and can achieve a near mirror finish. A combination of lapping film grade is preferred as being effective to achieve good heater planarization. This technique has been used on a CVD heater, to achieve a good finish with minimal heater dimensional damage. In this instance where the heater

had a "W" shaped distortion, mainly caused by redistribution of mechanical (machining and welding) stress after one and half years of usage, the amount of distortion being thick and wide. First rework polishing using 45 microns increased the removal rate, second polishing using 20 microns removed roughness, third polishing using 9 microns achieved a fine and smoother surface. Other combinations can be used as appropriate. A good surface finish minimises particle generation and improves temperature uniformity. Hence, the selection of lapping film grade affects repair effectiveness and the surface finish of the heater, as well as minimising dimensional damage.

Further, although in this embodiment, the oil is spread onto the pedestal surface, it could be onto the back of the lapping film (or even on both surfaces). Other adhesive methods are also possible.

An amount of 100% IPA is put onto the outer surface of the lapping film (S110), as a lubricant. The polisher is placed onto the pedestal heater surface, with the lapping film and IPA in connects with the surface. Pressure is applied and the polisher is lapped around the top of the pedestal in a figure of eight pattern (S112), for about 3 to 5 minutes. This is to polish the surface, in what is in effect a sanding action. If the contact surfaces begin to dry up (S114), more IPA is added (S110). Although the IPA is added here to the surface of the diamond film, it could be directly onto the pedestal surface or onto either or onto both.

After this, the polisher is removed and the pedestal heater is cleaned with a wipe and allowed to dry. Any dirt is also removed from the heater grooves using a vacuum (S116).

Once a polishing attempt has been completed, the pressure is tested (S118), as with the prior art. If it passes, the pedestal can go back on-line (S122). If it fails to make the appropriate pressure, more IPA is applied (S110) and polishing restarts. Sometimes this may require a new polisher to be made up. Polishing attempts can be repeated until the open chamber vacuum pressure test reaches the required specification, or it becomes apparent that the pedestal can not be repaired this way – for example if the pressure is not improving or is improving too little each time.

Although as described above, most, if not all actions are carried out manually, it is possible to automate many if not all of the steps. Various controls and actuators can be used to complete some or all of the polisher construction steps and/or a polishing machine can be provided with the constructed polisher to polish the pedestal.

Using the present invention, the inventors have found that with improved planarization, temperature uniformity in a heated wafer tends to be better. As a result deposition uniformity become better after repair, thus saving the heater from the need to replacement so soon. This invention extends the useful life of the pedestal by one to one and a half years, rather then about six months. The pedestal heater can be repaired to maintain a 32 Torr backside pressure for several wetclean PM. Thus, it can be reused again and again, until it cannot be repaired within a standards PM cycle time (as this impacts on machine uptime), at which point replacement occurs. The polishing process can take less than half an hour rather than the previous process taking nearly 2-3 hours. There is therefore less down time due to repairs and the process becomes more cost effective.

The use of the invention reduces backside pressure faults. It increases the useful time before such faults become intolerable. This results in fewer wetcleans, hence increased equipment uptime and more production days in between.

This invention is equally useful in photolithographic scanners, CVD, PVD and etching chambers or semiconductor apparatuses that require heating or a vacuum or mechanical devices to secure the position of a wafer to the pedestal surface and elsewhere where pedestals suffer through use.